

FINAL REPORT

PROPRIETARY TESTING OF MODIFIED DHANAWAS
SOLAR WATER HEATER SYSTEMS

Submitted to
RALLIS INDIA LIMITED

By

TATA ENERGY RESEARCH INSTITUTE
NEW DELHI

JANUARY 1988

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INSTITUTE, NEW DELHI

Principal Investigator Dr Ashok Gadgil

Associated Researcher Mr Arvinder Singh

1. Background

The first progress report of the project was sent to Rallis in October 1987. In early December 1987, we handed over to Rallis detailed sketches of the water heater including the bill of materials. Twentyone black and white photographs of the completed system were also mailed to Rallis in the third week of December. This final report provides confirmation of the simulation technique for system performance, the performance at halfhour intervals in New Delhi on December 23, 1987 has been compared with predictions from our simulations. The agreement is consistent with the comparison made earlier with the system performance of October 9, 1987. The maximum discrepancy between the predicted and observed water temperatures is less than 2°C. This gives us confidence that predictions of system performance in the other five cities for January 18 are reasonable and reliable.

2. Construction details

The construction details for the system, together with the bill of materials are provided in Appendix I. As discussed with Rallis during December, TERI has agreed to send one of its researchers to Bombay (at Rallis's cost) to provide close guidance for fabrication of the first unit. The maximum duration of stay in Bombay for TERI's researcher will not exceed ten days.

Construction details and bill of materials for the drain-down storage tank are given in Appendix II. In the tank fabricated at TEEL, we conducted experiments to ensure that overnight drop in temperature of stored water is acceptably small. The observed results are given in Table 1.

Table 1
Overnight Temperature Drop in Insulated Tank

ate	Initial temperature of water (T_1)	Time of filling the tank (t_1)	Minimum Ambient Temperature (T_m)	Temperature of water next morning (T_2)	Time of measure- ment next day (t_2)	$(T_1 - T_2)(16)$ $(T_1 - T_m)(t_2 - t_1)$
ec 1, 87	40.2°C	17:30 hours	10.1°C	37.0°C	11:30 hours	0.044
ec 2, 87	65.2°C	17:30 hours	7.4°C	61.2°C	9:00 hours	0.074
ec 2, 87	59.4°C	17:30 hours	7.9°C	55.2°C	8:00 hours	0.089

It appears that the drop in water temperature from an overnight storage of approximately 16 hours is about 0.066 times the difference in temperature between the initial water temperature and the nighttime minimum ambient temperature. This appears entirely acceptable. In fact, for warmer southern climates, lower levels of insulation and larger heat loss coefficients may be acceptable, thereby lowering the storage tank costs.

3. Simulation of Thermal performance

The predicted and observed thermal performance of the water heater is compared in Figure 1. The agreement is good ;

The predicted mean water temperatures for six cities on January 15 as a function of time are shown in Figures 2-7. For these simulations we have used radiation and climatic data available from standard handbooks [1]. We have also assumed that the supplied water temperature equals the ambient temperature of that city at 9 a.m.

4. Certification of the system by DNES

As indicated by letter to TEHL, the latter will deliver an entire system consisting of two water heaters with support stands and insulated drain-down storage tank to the Solar Energy Centre of DNES for their certification programme.

TEHL will also independently pursue with DNES the matter of obtaining subsidy approval for 50 litre systems.

An additional set of 21 photographs of the system is enclosed.

References

1. Mani, A., Handbook of Solar Radiation, New Delhi, Allied Publishers (1981)

NEW DELHI
DEC 23, 1987

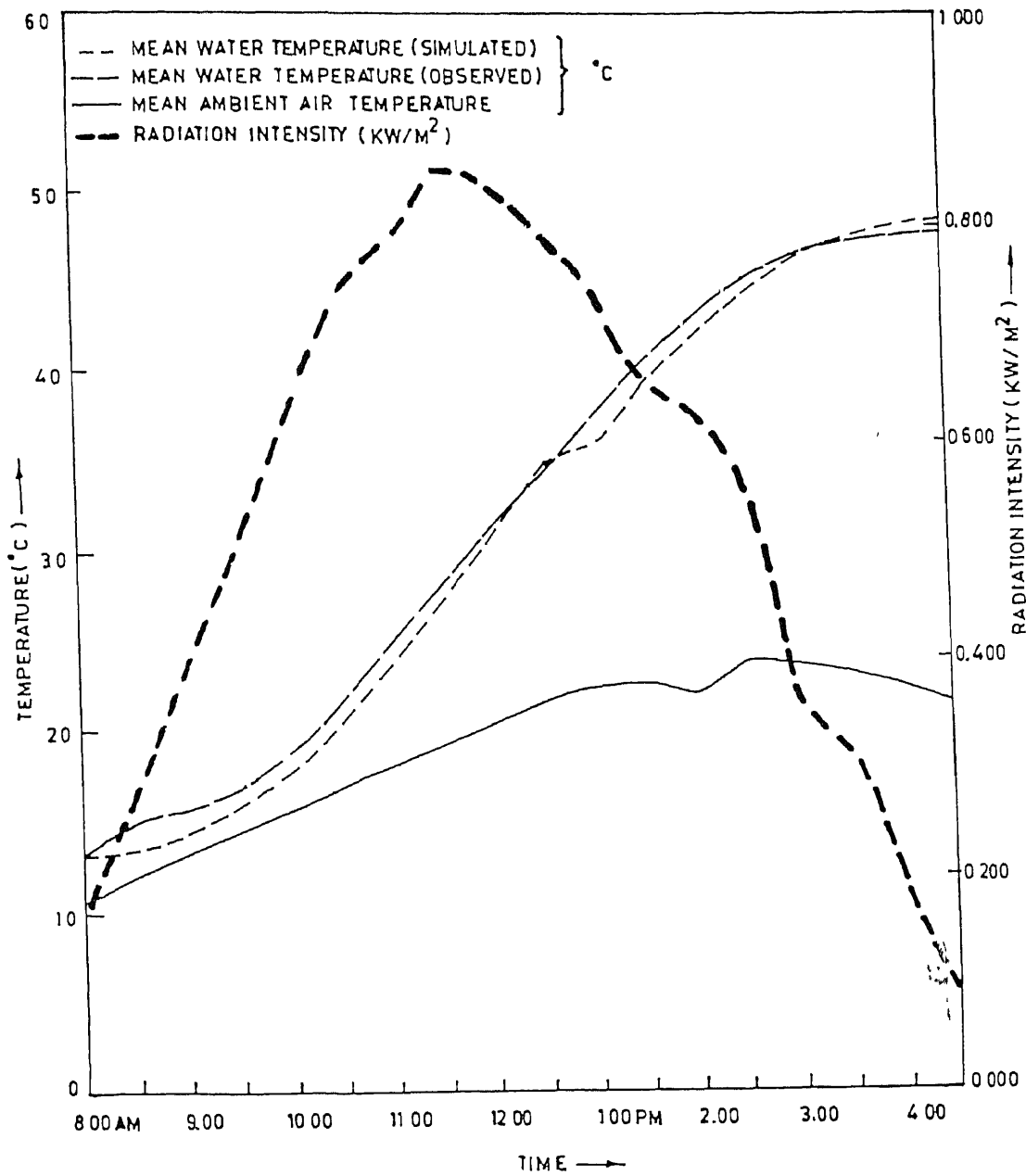
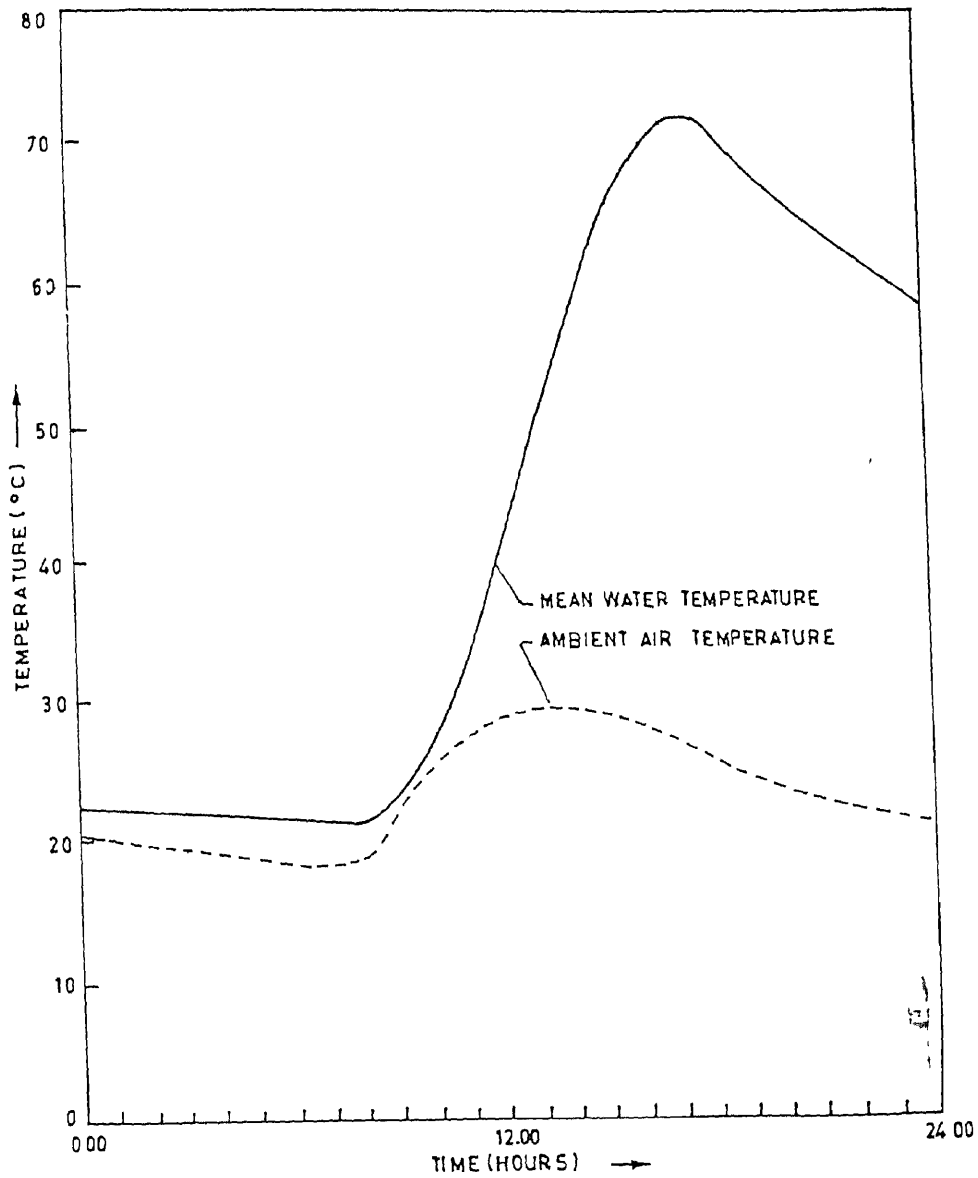


Figure 1

BOMBAY

JAN 15

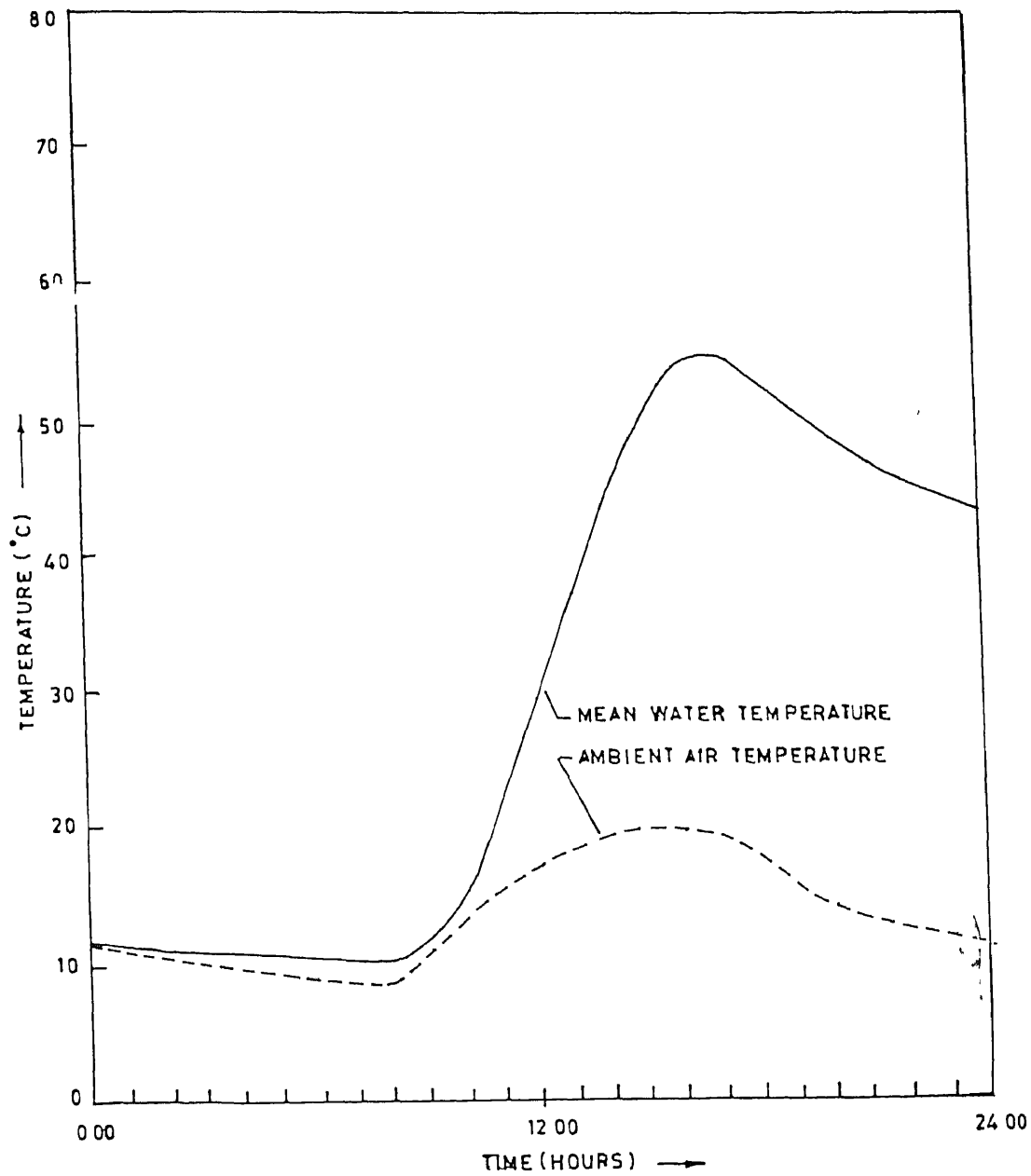


Simulated Performance of the TERI-RALLIS Solar
Water Heater

Figure 2

NEW DELHI

JAN 15

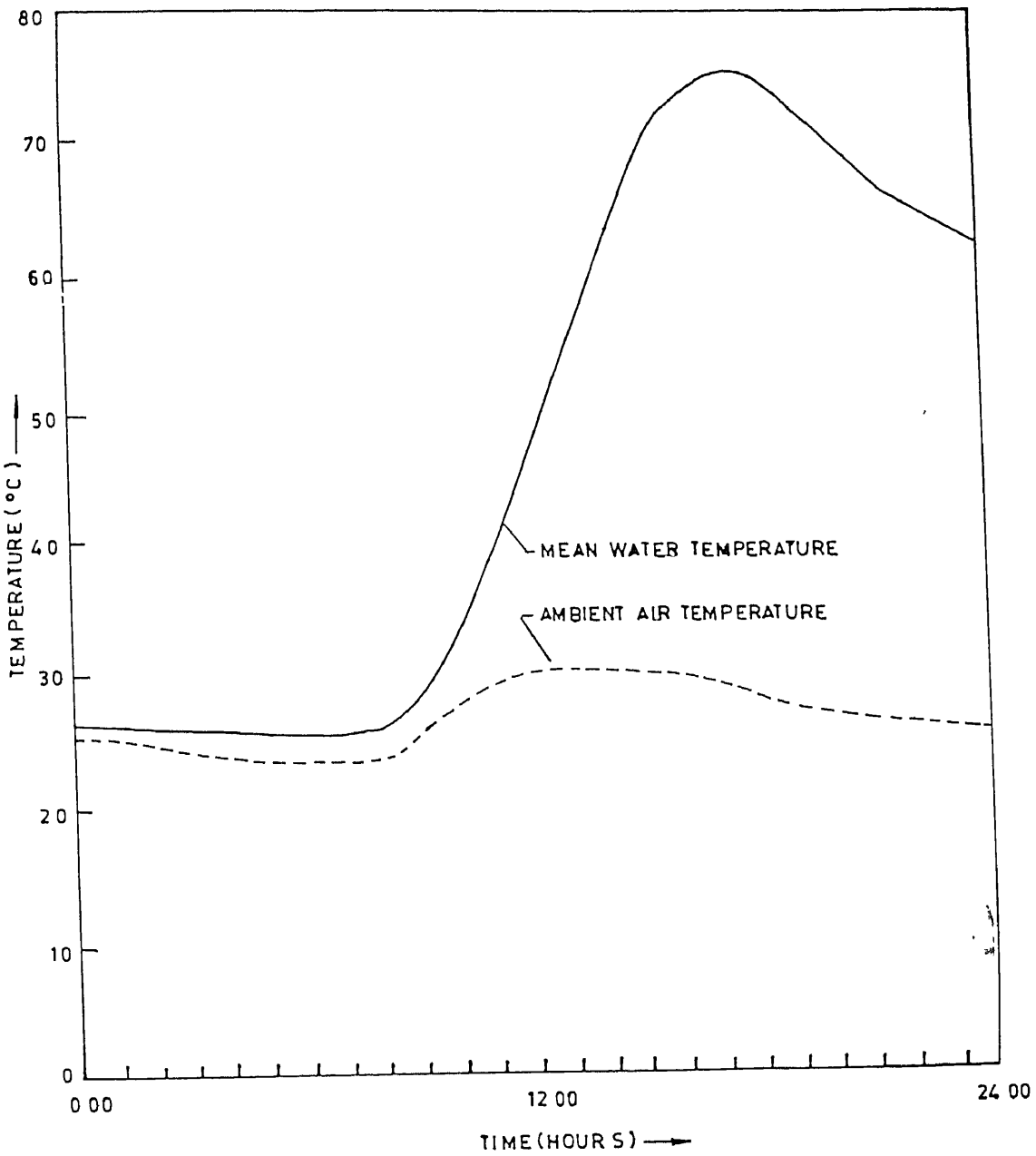


Simulated Performance of the TERI-RALLIS Solar Water Heater

Figure 3

TRIVANDRUM

JAN 15

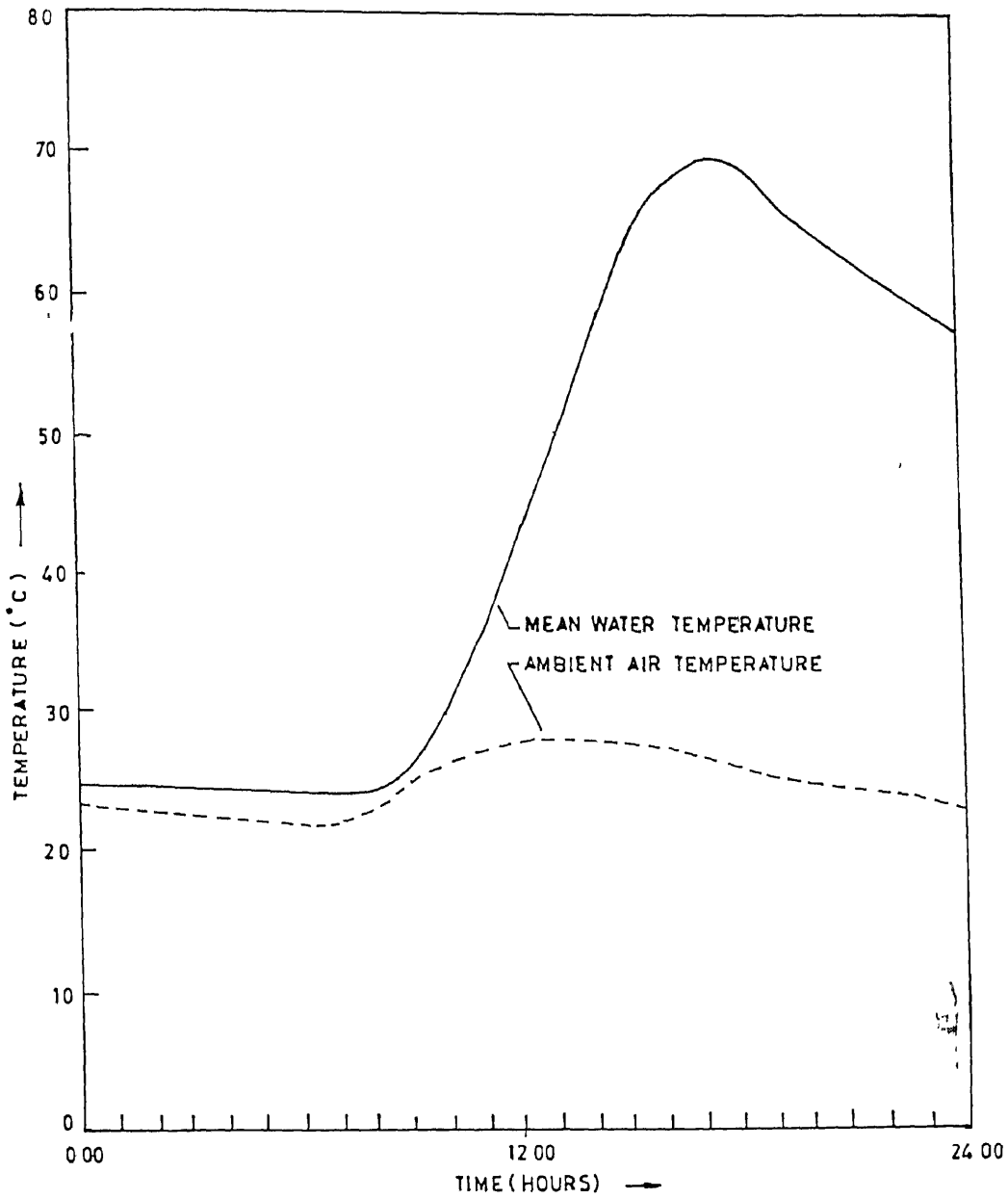


Simulated Performance of the TERI-RALLIS Solar Water Heater

Figure 4

MADRAS

JAN 15

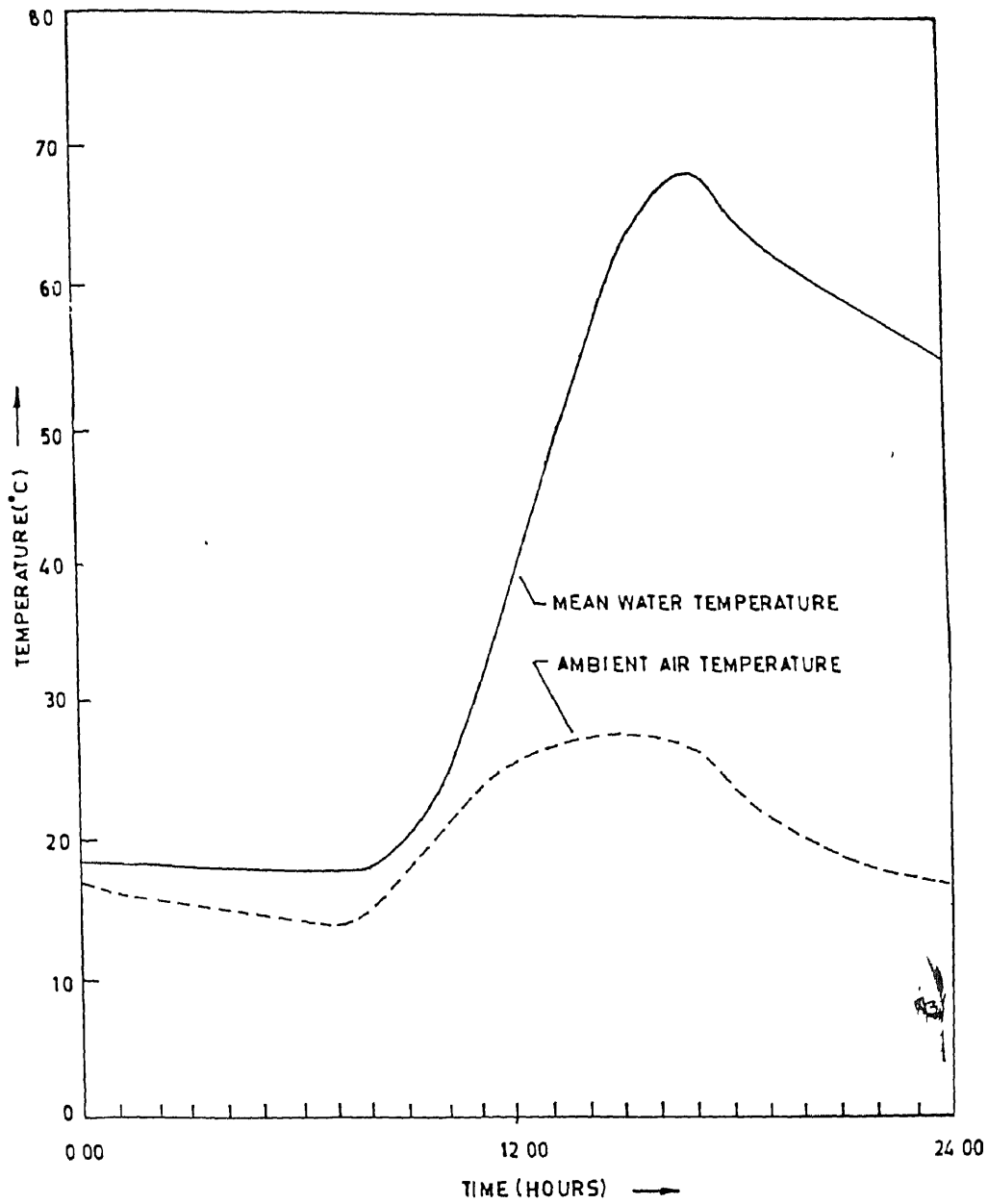


Simulated Performance of the TERI-RALLIS Solar
Water Heater

Figure 5

NAGPUR

JAN 15

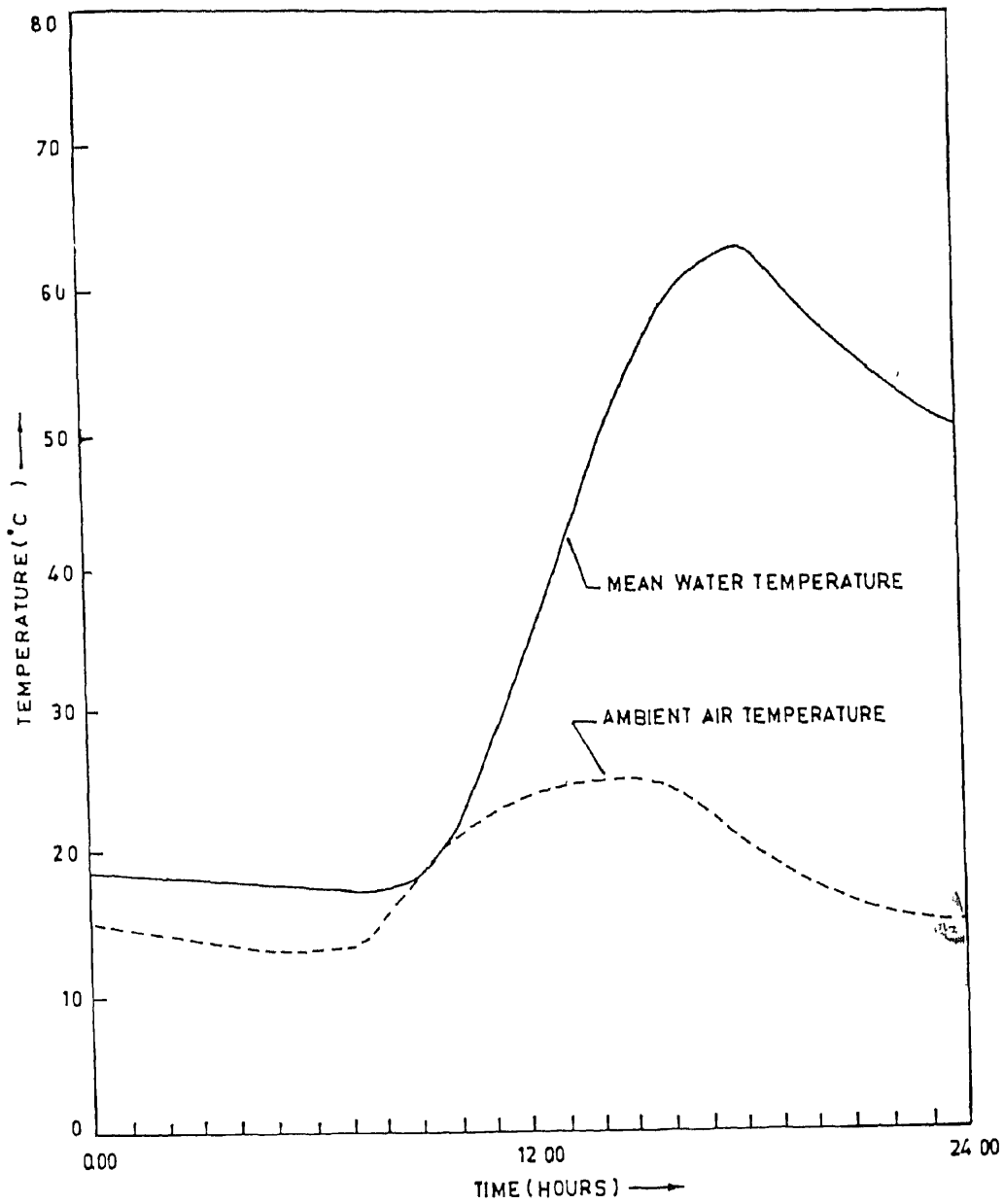


Simulated Performance of the TERI-RALLIS Solar Water Heater

Figure 6

CALCUTTA

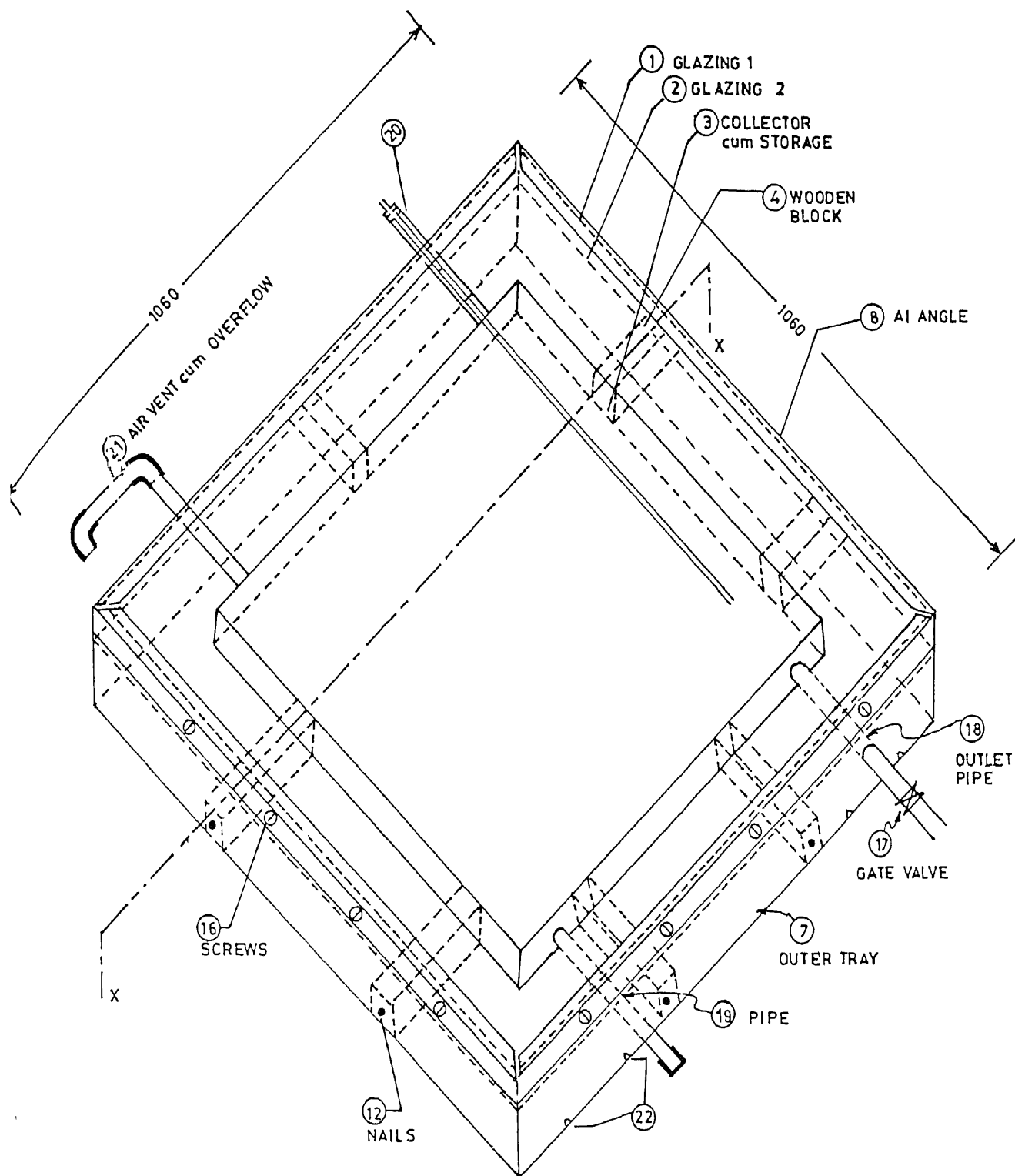
JAN 15



Simulated Performance of the TERI-RALLIS Solar
Water Heater

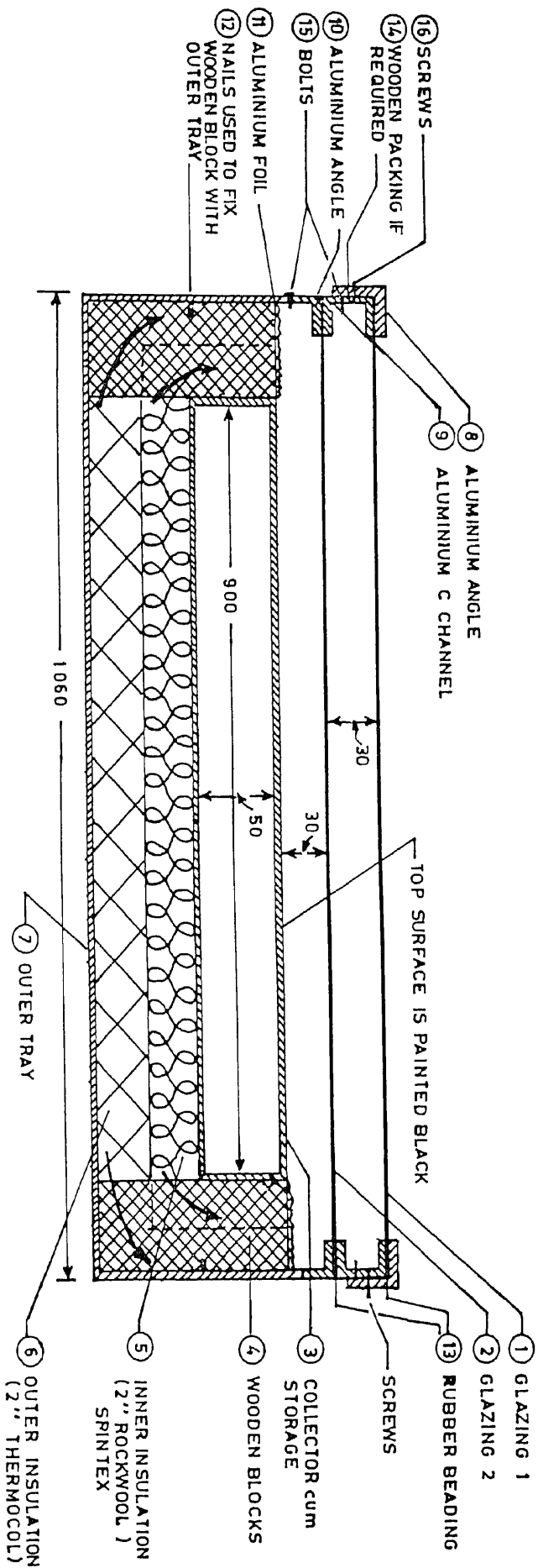
Figure 7

APPENDIX I



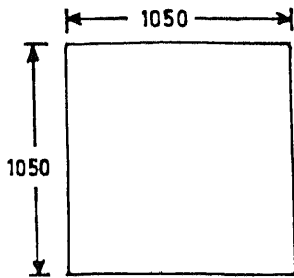
DRAWING 1

ITEMS NOT SHOWN IN THIS SKETCH-		
Item No	Description	Shown in Drawing No
5,6	Insulation	2
10	C- Channel	2
11	Al Foil	2
9	Al C- Channel	2
13	Rubber beading	2
14,15		2



DRAWING 2

(1) Glazing 1:



2 mm Solar Grade Acrylic Sheet

Commercial Name : Acrypol-S

(manuf. & mark, by GSFC, Vadodara)

Size: 1050 x 1050 (mm)

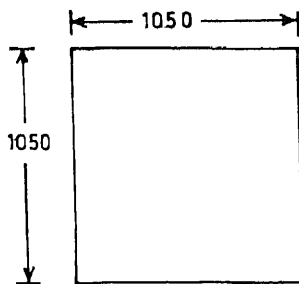
Transmittivity (γ) = 0.9

It can be cut with sharpened tip of a broken piece of Hacksaw blade

Shape:



(2) Glazing 2:



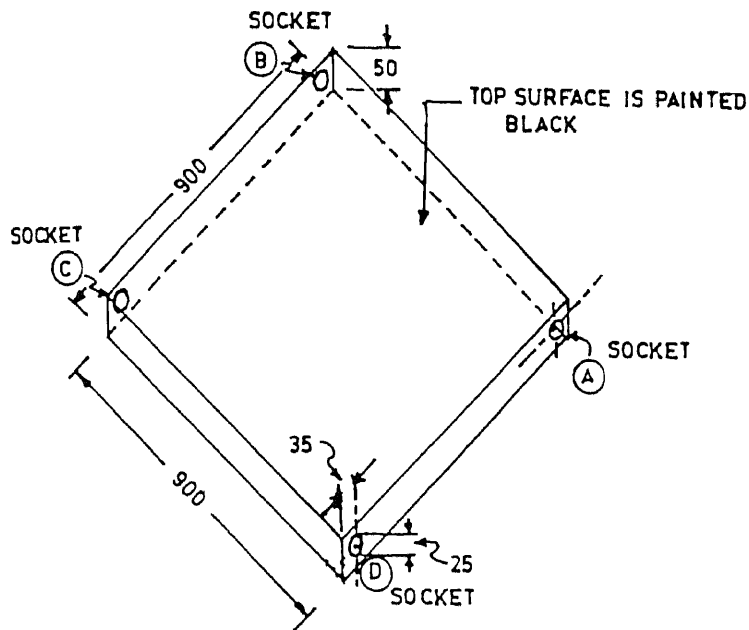
4 mm Glass (non-tempered, good make eg. "Triveni")

Transmittivity (γ) = 0.80

Size: 1050 x 1050 (mm)

It can be cut from a standard 6' x 4' sheet using diamond edged glass cutter.

(3) Collector Cum Storage:



It is made of M.S. Sheet of 20 Gauge.

(A), (B), (C), (D)

Sockets of 25 mm dia. welded to side faces at a distance of 35 mm from the edge of the box. Distance is from edge to centre of the socket.

Sequence of manufacturing process:

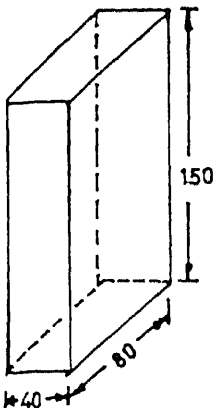
make M.S. tank first

weld the 4 sockets of 25 mm dia. as shown above at positions (A), (B), (C) & (D)

get the whole assembly hot dip galvanized

paint the top surface of the tank with high quality (eg. "Nerolac") black board paint, after scrubbing it lightly with emery paper

Wooden Blocks: Used to support Collector-cum-storage (Item 3) within outer tray (Item 7) as following:



2 blocks on each side and bottom faces and 1 on top. These are nailed to the outer tray (Item 7) as shown in Sheets 1 & 2

, (6) Insulation: There are 2 different layers of insulation on the side and bottom of the collector-cum-storage.

Inner Insulation: 50 mm Resin-bonded Rock Wool ("Spintex") with

(5) following properties:

Density (ρ) = 40 Kg/m^3

Thermal Conductivity (K) = 0.0299 W/m.k

About 1.5 m^2 of Spintex is required per water heater unit

Outer Insulation: 50 mm Styrofoam ("Thermocol") with following

(6) properties:

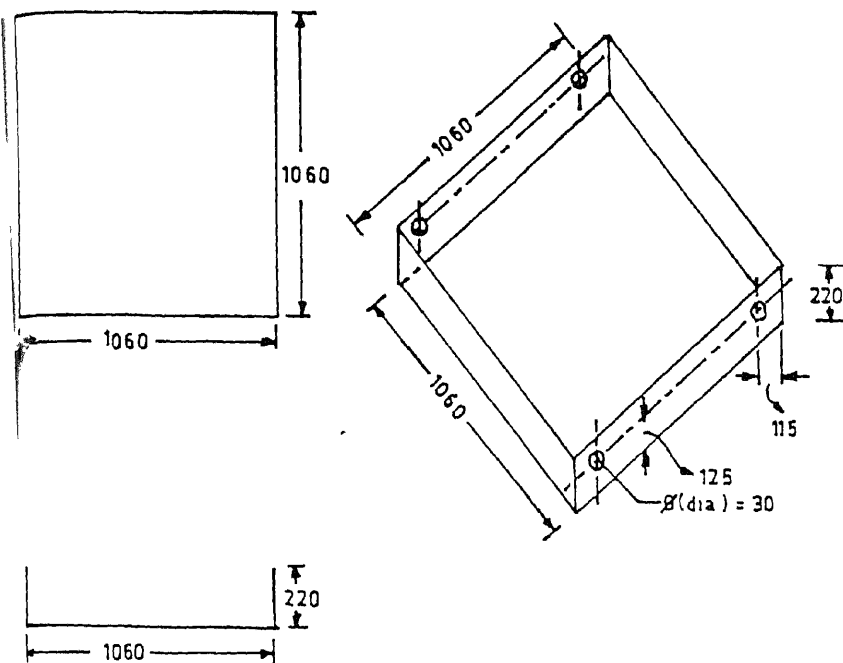
Density (ρ) = 16 kg/m^3

Thermal Conductivity (K) = 0.025 W/m.k

About 1.5 m^2 of styrofoam is required per water heater unit

On sides, inner insulation is Resin-bonded Rock Wool (50 mm) and outer insulation is styrofoam ("Thermocole"), 50 mm.

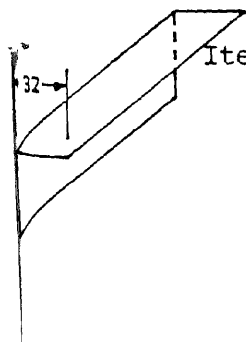
- 7) Outer Tray: The complete assembly of collector-cum-storage is placed inside outer tray. It has 5 sides, and it is made of 26 Gauge M.S. sheet



It should be painted from the outside.

4 Weep holes, at lowest edge, of dia. 4mm

- 8), (10) Aluminium Angle: Size: $1\frac{1}{4}$ " (31.75 mm), Thickness = 2 mm
about 9 m of Aluminium angle is required

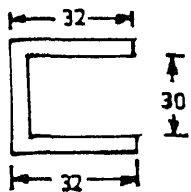


Item (10) is used to support the lower glazing ie. Glazing (2) (Item 2)

It is bolted to the outer tray using 4 bolts on each side. Bolt size is $\frac{25 \text{ mm}}{\text{dia } 3 \text{ mm}}$

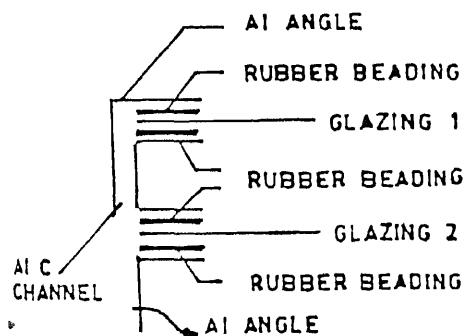
Item (8) is used to frame and assemble the Glazing (1) (Item 1). It is screwed with outer tray using 4 selfthread screws on each side of length 25 mm dia 3 mm

(9) C - Channel of Aluminium:



About 4.25 m of Al. C-Channel is required for 1 water heater unit
It is used to support the Glazing (1)
ie. Item (1), Channel Wall thickness 2 mm

P.S. : Rubber beading is provided wherever Item (8), (9), (10) are in contact with glazing material. It is done to protect the glazing and to provide better grip
Rubber beading (13) is used on 4 surfaces as shown in Drawing 2.

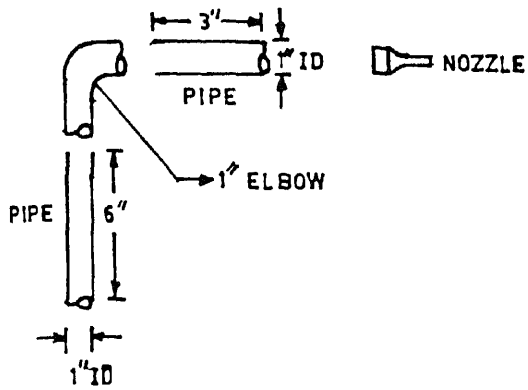


(12), (15), (16) : 12: nails used to fix wooden block to outer tray
15: bolts used to fix Al. Angle
16: selfthread screws used to fix C-Channel & Al. Angle together

- (11) Aluminium Foil: One layer of Al. Foil is put on top face of the side insulation, to prevent direct exposure of thermocole to sunlight,
- (14) Wooden Packing: It should be inserted between any empty space left out between Al. Angle and outer tray.
- (17) Gate Valve: It is put at the outlet pipe of the collector.
Size is 1".
- (18) Outlet Pipe (Drainage):
Size: Dia: 1" ID
Length: 6"
This is fitted to the socket (A) shown in drawing of Item (3) on page (4), other end of the pipe is fitted with the gate valve.
- (19) Pipe: dia: 1" ID
Length: 6"; fitted to socket (D) shown in drawing of Item (3) on page (4). This pipe is a redundant pipe and is required only to facilitate the process of hot-dip galvanization and gives a better design structurally. It should be blocked permanently with the end cap.

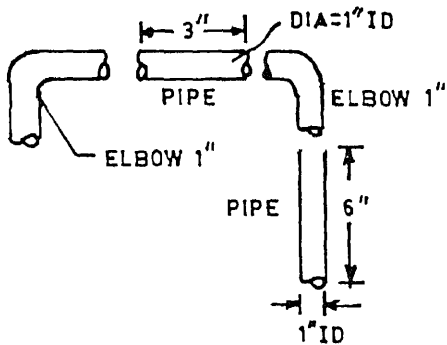
(20) Inlet Pipe:

It is meant to pour water in the collector cum storage.



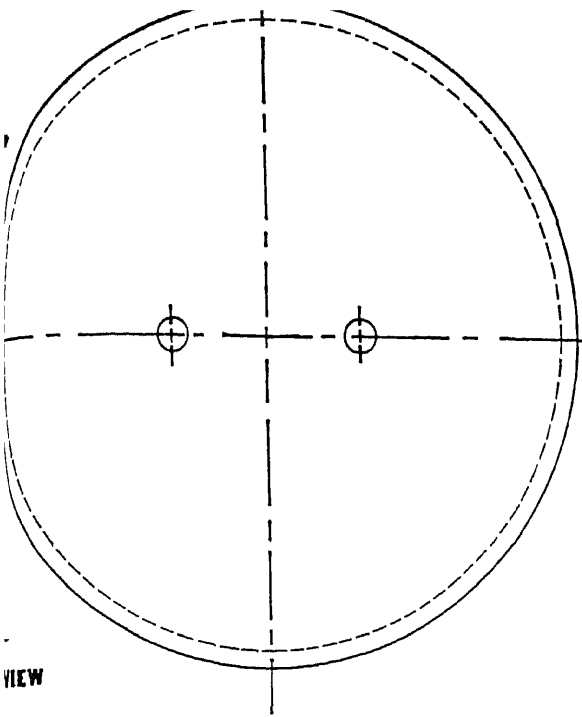
(21) Air Vent cum Overflow:

It is meant to be an air vent and an indicator of overflow. It consists of 4 components as shown in figure.

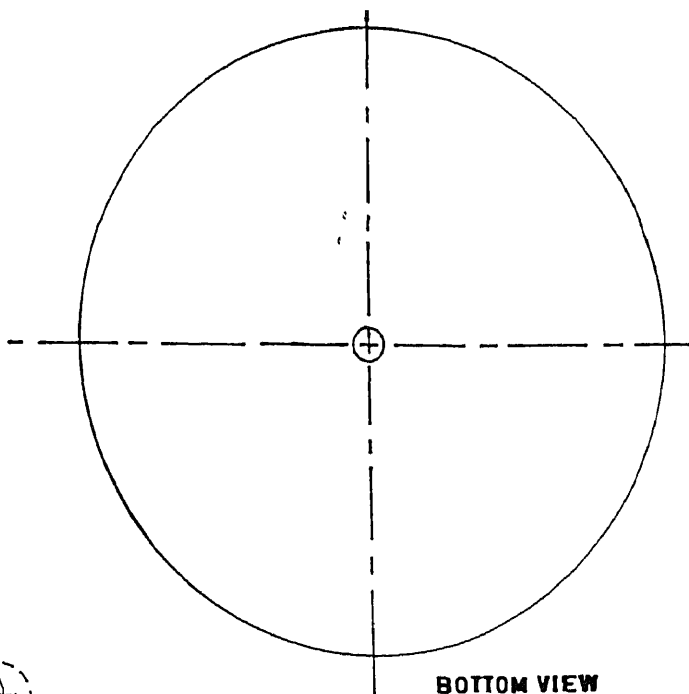


- (22) 4 mm dia holes to prevent water stagnating inside the unit in case of a water leak.

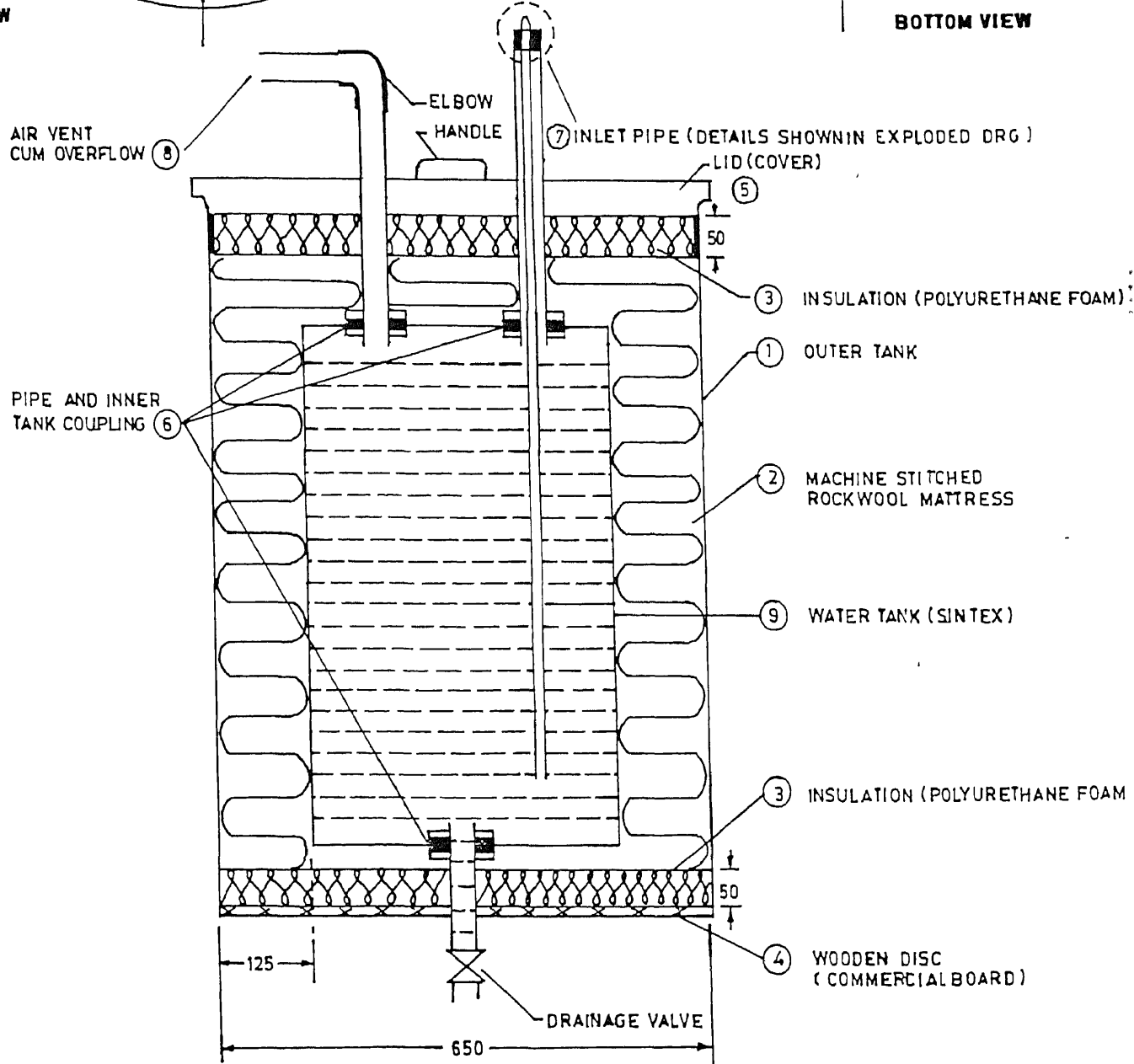
APPENDIX II



VIEW

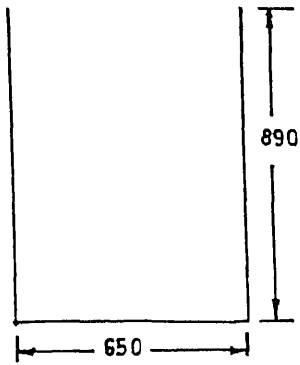


BOTTOM VIEW

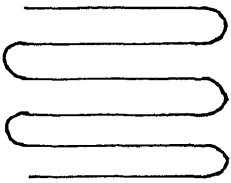


OVERNIGHT HOT WATER STORAGE TANK
CAPACITY: 100 LITRES

- (1) Outer Tank : Made of G.I sheet (26 gauge)
(Cylindrical) Dimensions are shown in sketch.



- (2) Insulation : It is Machine Stitched Rock Wool.



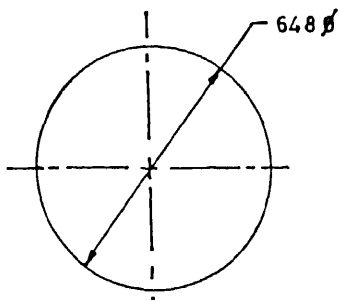
- (3) Insulation : Polyurathene foam with following properties.



Thermal Conductivity $K = 0.016 \text{ W/m}^{\circ}\text{K}$

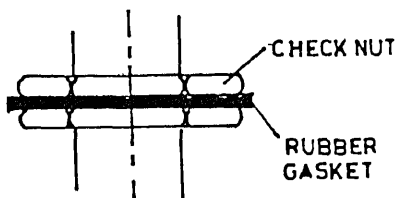
Density (P) = 32 Kg/m

- (4) Wooden Disk : It is used to support the inner tank and insulation outside the inner tank. It is a disk cut out of a commercial board (19 mm)

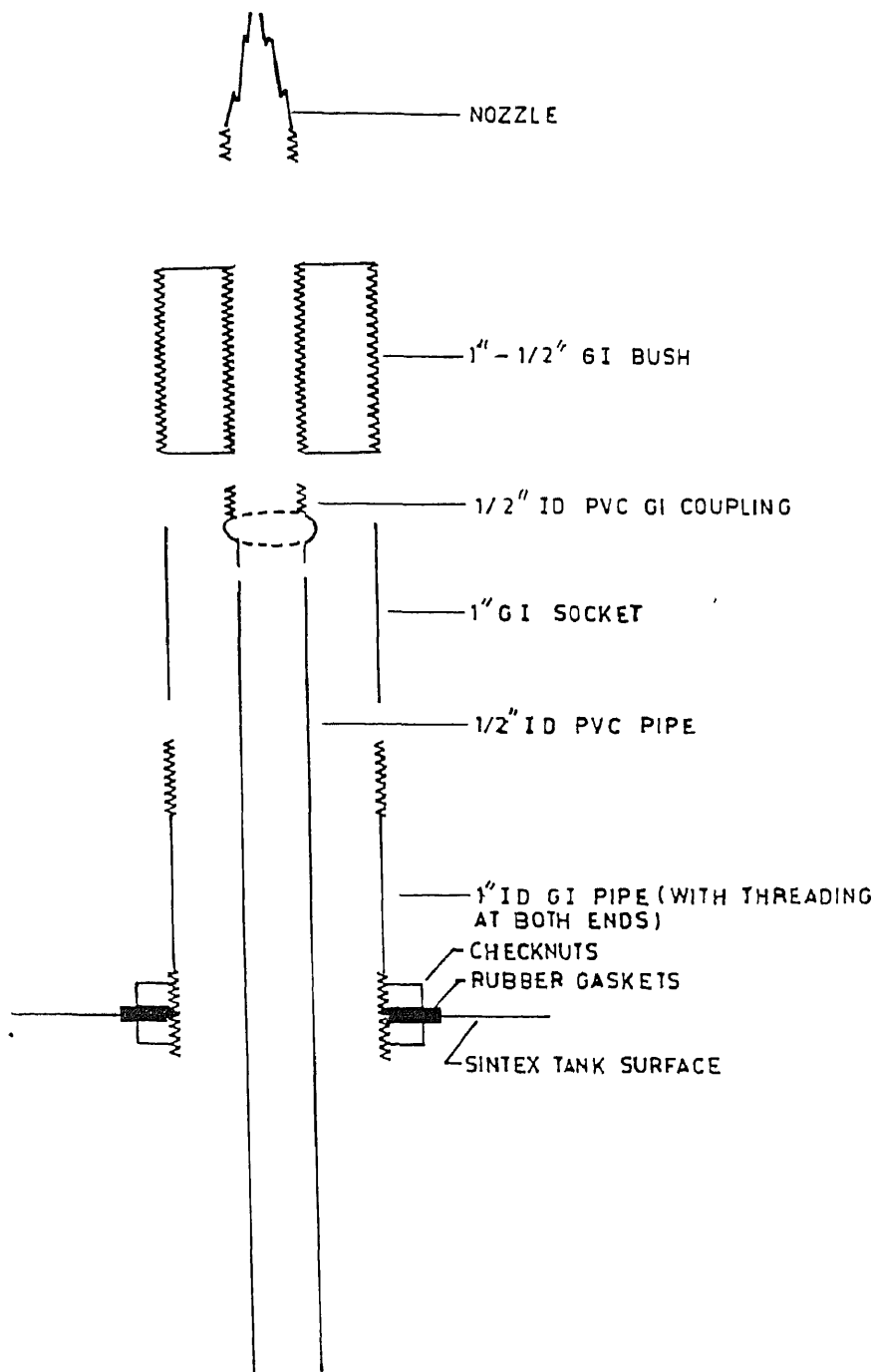


- (5) Lid (Cover) : To cover the entire tank.

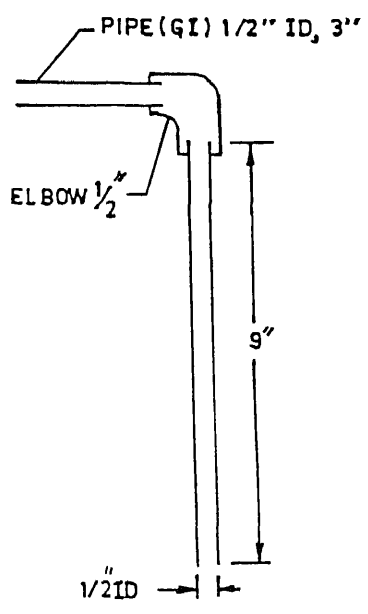
- (6) Pipe & Inner Tank Coupling :



(7) INLET PIPE ASSEMBLY
(EXPLODED)



(8) Air Vent-cum-overflow



(9) Water Tank (100 ltrs)

Supplier: Sinter Plast Containers
(Sintex)

Top lid is sealed with Araldite.

